

MACROHETEROCERAN DIVERSITY IN TEMPERATE FOREST AT MEIFENG

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ABSTRACT—Monthly light-trap surveys were conducted at Meifeng, Nantou county, Taiwan in 1990 and 1991. A total of 200 species of macroheteroceran species are recorded, most of which are in the families of Geometridae and Noctuidae. Species-abundance relations are examined and several diversity indices are calculated. The relative abundance of trapped moth species fits a log-normal model, which indicates that the moth community in this habitat is in stable equilibrium. There is a significant relationship between numbers of moth and such climatic factors as temperature, and rainfall. Observed values of environmental variables can be used to predict species abundance. The possibility of using macroheteroceran species for ecological monitoring is discussed.

KEY WORDS: Macroheterocera, community, diversity, host plant, ecological monitoring, Taiwan.

INTRODUCTION

Taiwan is one of a chain of islands near the Asian continent, lying about 145 kilometers from the Chinese mainland. The topography is rugged, with the greater part of the land area at above 1000 m. Rivers originating in central mountain range are short and fast-running. The diverse variation topography is much affected by the flooding and erosion. The island is in the subtropical zone. Because of the high mountains, it exhibits considerable variation in climate and habitat. Although small in size relative to the continental land masses, Taiwan has a diverse Lepidoptera fauna.

In Taiwan there is widespread ongoing habitat destruction. Most of the tropical and subtropical virgin forest in lowland was removed as the human population grew. Previously undisturbed lands are under heavy pressure for conversion to meet human needs (Severinghaus, 1977). This raises concerns about the future of the island's flora and fauna, including those Lepidoptera that may have specialized habitat requirement. Investigations are needed to evaluate the status of Lepidoptera in Taiwan, to assess the impact of habitat destruction

on populations, and to design a monitoring system for Lepidoptera.

This paper examines some of the community-level structure evident in temperate forest-inhabiting macroheteroceran species sampled with a light trap at Meifeng, Nantou County, Taiwan. The fixed site was chosen in order to facilitate the study of seasonal changes in insect community structure.

In this study the forest macroheteroceran community was defined operationally as those species appearing in the light trap. These samples were utilized to explore the general structure of the moth community. The purpose of this study included estimating the overall species composition at the study site, correlating species properties with environmental factors, studying temporal and spatial variation in species pattern, and contributing to the design of a Lepidoptera monitoring system.

Study Site

The study area is at about 121° 11' E 24° 05' N (Figure 1). It is near the temperate forest of the Water Resource Conservation area of the National Taiwan University Montane Horticultural Experimental Station at about 2150 m.

This area is typical of medium or high-altitude temperate forest in central Taiwan, with cold, dry winters, relatively cool, moist summers, and considerable rainfall during the typhoon season. Mean annual temperature was 13.23°C in 1990 and 12.77°C in 1991. Annual total rainfall was 199.98 cm in 1990 and 375.74 cm in 1991, with three typhoons visiting Taiwan during the summer of 1991.

The forest is dominated by trees such as *Alnus formosana* Makino (Betulaceae), *Castanopsis carlesii* (Hemsl.) Hayata, *C. formosana* (Skan) Hayata, *Cyclobalanopsis longinix* (Hayata) Schott, *C. morii* (Hayata) Schott. (Fagaceae), *Actinodaphne nantoensis* (Hay.) Hay., *Cinnamomum smophloeum* Kanehira, *Listea acuminata* (Blume) Kurata, *L. mushaensis* Hayata, *Persea obovatifolia* (Hayata) Kostermans, *Phoebe formosana* Hayata (Lauraceae), and *Trochodendron aralioides* Siebold & Zucc. (Trochodendraceae). The understory and ground cover consist of the seedling and saplings of the dominants plus such plants as *Debregeasia edulis* (Sieb & Zucc.) Wedd., *Polygonum chinensis* L., *P. posumum* Buch.-Han, ex Don. (Polygonaceae), *Eriocapitella vitifolia* (Buch.-Ham) Nakai, *Clematis gouriana* Roxb. (Ranunculaceae), *Actinidia callosa* Lindl. var. *formosana* Finet & Gagnep. (Actinidiaceae), *Eurya acuminata*, *E. strigillosa* Hayata (Theaceae), *Rubus rolfei* Vidal, *R. buergeri* Miq. (Rosaceae), *Acer kawakami* Koidz. (Aceraceae), *Impatiens* spp. (Balsaminaceae), *Ilex asprella* Champ. (Aquifoliaceae), *Tripterospermum taiwanense* (Masam.) Satake (Gentianaceae), *Cirsium kawakamii* Hayata, *Senecio nemorensis* L. (Compositae), *Mis canthus floridulus* (Labill.) warb. ex Schum & Laut. (Gramineae) (Chen, 1991). The 232 species in 83 families of vascular plants are investigated by Chen and Wang (1992).

MATERIALS AND METHOD

1. Moth Sampling

Monthly surveys were conducted during 1990 and 1991. A battery-operated portable light trap using UV light tubes was used to attract nocturnal moths. Light sensor was used to control the exposure of the UV light. The light exposure period was about 12 hours. Surveys were conducted about once monthly at each study site for a period of one

year. Catches were removed from the trap, the Lepidoptera were pinned in boxes, and the remaining insects preserved in alcohol. A reference collection of one example of every species trapped during 1990 and notes of the night's catch were made as the catch was removed.

2. Data analysis

Species-abundance relations were calculated with the method described by Ludwig & Reynolds (1988). richness indices were calculated by using Margalef's (1958) index (R1) and Menchinick's (1964) index (R2). Diversity indices were calculated by using Simpson's (1949) index (Lambda), Shannon-Wiener's index (H) (Margalef, 1958), Hill's first diversity number (N1) and Hill's second diversity number (N2). Evenness indices were calculated by using E1 (Pielou, 1977), E2 (Sheldon, 1969), E3 (Heip, 1974), E4 (Hill, 1973) and E5 (Hurlbert, 1971). Cluster analysis and dendrogram grafting followed the NTSYS-pc developed by Rohlf (1988).

RESULTS AND DISCUSSION

1. Species composition of the moth community

Results of the number of species, number of individuals, and frequency distribution of families and superfamilies are presented in Table 1. Most of the collected macroheteroceran species are included in the table. In 1990, a total of 146 species and 1335 individuals of moths were collected. About 46% of species and individuals were in the Geometridae, the dominant group. Minor groups include Arctiidae, Notodontidae, Eupterotidae, Drepanidae, Lymantridae, Sphingidae, Lasiocampidae, Saturniidae, Bombycidae, Hypsidae, Thyatiridae, and Cyclidiidae. The approximate numbers of species and individuals of Noctuidae, the second dominant group are given next to the Geometridae. Species and monthly numbers of individuals trapped in 1990 are listed in Table 2.

In 1991, a total of 144 species and 1565 individuals were collected. About 50% of species and individuals were in the Geometridae. The minor group were similar to those trapped in 1990, but saturniids did not appear in the light trap in 1991. Species and monthly numbers of individuals

Table 1. Number of species and number of macroheteroceran moths according to family during a 1990-1991 survey at Meifeng, Nantou, Taiwan (N=18)

Year Superfamily family	1990				1991				1990+1991			
	sp.no.	%	moth no.	%	sp.no.	%	moth no.	%	sp.no.	%	moth no.	%
Drepanoidea												
Drepanidae	5	3.4	69	5.2	4	2.8	36	2.3	6	3.0	105	3.6
Cyclidiidae	1	0.7	1	0.1					1	0.5	1	0.1
Thyatiridae	1	0.7	2	0.2	1	0.7	2	0.1	1	0.5	4	0.2
Geometroidea												
Geometridae	67	45.9	617	46.2	79	54.9	1099	70.0	98	49.0	1753	60.4
Bombycoidea												
Lasiocampidae	3	2.1	9	0.7	2	1.4	25	1.6	3	1.5	34	1.2
Eupterotidae	1	0.7	62	4.6	1	0.7	18	1.2	1	0.5	80	2.8
Bombycidae	1	0.7	9	0.4	1	0.7	1	0.1	1	0.5	10	0.3
Saturniidae	5	3.4	12	0.9					5	2.5	12	0.4
Sphingoidea												
Sphingidae	5	3.4	9	0.7	3	2.1	21	1.3	6	3.0	30	1.0
Noctuoidea												
Notodontidae	17	11.6	65	4.9	12	8.3	49	3.1	21	10.5	114	3.9
Lymantridae	2	1.4	24	1.8	4	2.8	32	2.1	4	2.0	56	1.9
Arctiidae	17	11.6	272	20.4	15	10.4	143	9.1	22	11.0	415	14.3
Noctuidae	22	15.1	184	13.8	17	11.8	124	7.9	30	15.0	308	10.5
Total	146		1335		144		1565		200		2900	

trapped in 1991 are listed in Table 3.

In two years' survey, a total of 200 species and 2900 individual moth were collected, including 98 species in Geometroidea, 77 of Noctuoidea, 10 of Bombycoidea, 8 of Drepanoidea, and 6 in Sphingoidea. Overall, geometrids and noctuids are the dominant groups. The species and monthly numbers of individuals trapped during 1990 to 1991 are listed in Table 4. The relationships of the two years' faunistic data shown by Sorensen's index of similarity for taxonomic comparison (0.5896), which shows relatively low similarity between two years. This is probably due mainly to habitat differences at the two locations. The relationships of 18 months' faunistic data are shown by the indices of similarity shown in Appendix 1. These

are most easily appreciated by reference to the dendrogram (Appendix 2) which shows:

- (i) a very large taxonomic disparity between the samples of February and March 1990.
- (ii) A relatively low overall similarity between monthly samples, including those from adjacent months.
- (iii) Insignificant diversity changes at these two sampling locations over two years, and with no evident seasonal changes.

The following genera are most abundant in the temperate forest in central Taiwan: *Arichanna*, *Myrteta*, *Lomographa*, *Psyra*, *Abraxas*, *Ourapteryx*, *Menophra*, *Timandra* (Geometridae), *Oreta* (Drepanidae), *Thanatarctia*, *Miltochrista*, *Eospilarctia*, *Cyana*, and *Agylla* (Arctiidae).

Table 2. Moth catch data from 1990 light-trapping in the temperate forest at Meifeng, Nantou, Taiwan

Species	Feb.	Mar.	May	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Drepanoidea										
Drepanidae										
<i>Canucha miranda</i>	*	*	*	*	*	1	*	*	*	1
<i>formosicola</i> Matsumura										
<i>Macrauzata minor</i> Okano	*	*	*	4	*	1	3	*	*	8
<i>Nordstroemia lilacina</i> (Moore)	*	*	*	*	*	*	*	2	*	2
<i>Oreta brunnea</i> Wileman	*	*	7	12	*	15	4	3	*	41
<i>Oreta extensa</i> Walker	*	*	4	5	*	6	1	1	*	17
Cyclidiidae										
<i>Cyclidia substigmata</i> (Hubner)	*	*	*	1	*	*	*	*	*	1
Thyatiridae										
<i>Tethea watanabei</i> (Matsumura)	*	*	1	1	*	*	*	*	*	2
Geometroidea										
Geometridae										
<i>Abraxas</i> sp.	*	*	8	*	*	*	*	*	*	8
<i>Abraxas taiwanensis</i> Inoue	*	*	*	*	*	*	*	6	*	6
<i>Abraxas suspecta</i> Warren	*	*	*	*	*	*	*	17	*	17
<i>Abraxas tenuisuffusa</i> Inoue	*	*	*	*	*	*	*	4	*	4
<i>Alcis admissaria</i> undularia Wileman	*	*	*	*	*	*	*	24	*	24
<i>Alcis plebeia</i> Wileman	*	*	*	*	*	*	*	20	*	20
<i>Alcis variegata</i> subochrearia (Wileman & South)	*	*	*	*	*	*	*	19	*	19
<i>Arichanna amoena</i> Bastelberger	*	*	*	*	*	*	*	1	1	2
<i>Arichanna fumigata</i> (Bastelberger)	*	*	*	*	*	*	*	28	*	28
<i>Arichanna</i> sp. 1	*	*	17	*	*	*	*	*	4	21
<i>Arichanna</i> sp. 2	*	*	*	*	*	*	*	2	*	2
<i>Cassyma deletaria</i> (Moore)	*	*	*	*	*	*	*	*	2	2
<i>Cassyma</i> sp.	*	*	*	*	*	*	*	*	1	1
<i>Diplurodes yestitus fuscovestitus</i> Inoue	*	*	*	*	*	*	*	*	6	6
<i>Dysstroma calamistratum scalatum</i> Bastalberger	*	*	*	*	*	*	*	2	*	2
<i>Dysstroma cinereatum</i> (Moore)	*	*	*	*	*	*	*	2	1	3
<i>Dysstroma</i> sp.	*	*	*	*	*	*	*	2	*	2
<i>Ecliptopera muscicolor allobathra</i> Prout	*	*	*	*	*	*	*	18	*	18
<i>Ecliptopera recordans</i> Prout	*	*	*	*	*	*	*	3	*	3
<i>Electrophaes taiwana</i> Inoue	*	*	*	*	*	*	*	2	1	3
<i>Erebomorpha fulguraria</i> Walker	*	*	1	*	2	*	*	*	*	3

continued

Species	Feb.	Mar.	May	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
<i>Photoscotosia miniosata</i> (Walker)	*	*	*	*	*	*	*	2	2	4
<i>Photoscotosia</i> sp.1 (Bremer)	*	*	*	*	*	*	*	3	*	3
<i>Photoscotosia</i> sp.2	*	*	*	*	*	*	*	4	*	4
<i>Photoscotosia</i> sp.3	*	*	*	*	*	*	*	5	*	5
<i>Protonebula altera</i> (Bastelberger)	*	*	*	*	*	*	*	1	*	1
<i>Psyra conferta</i> Inoue	*	*	*	*	*	*	*	4	2	6
<i>Psyra cuneata</i> matsumurai Bastelberger	*	*	*	*	*	*	*	1	*	1
<i>Sibatania arizana</i> (Wileman)	*	*	*	*	*	*	*	2	*	2
<i>Tanaoctenia haliaria</i> (Walker)	*	*	*	*	*	*	*	10	2	12
<i>Timandra</i> sp.	9	1	36	*	5	9	*	9	*	69
<i>Trichopterigia</i> sp.	*	*	*	*	*	*	*	*	1	1
<i>Xandrames dholaria</i> Moore	*	*	1	2	2	*	*	*	*	5
Bombycoidea										
Lasiocampidae										
<i>Kunugia undans metanastroides</i> (Strand)	*	*	*	*	*	*	5	1	*	6
<i>Dendrolimus punctatus</i> (Walker)	*	*	2	*	*	*	*	*	*	2
<i>Syrastrena sumatrana</i> Tams	*	*	*	*	*	*	*	*	1	1
Eupterotidae										
<i>Palirisa cervina formosana</i> Matsumura	*	*	62	*	*	*	*	*	*	62
Bombycidae										
<i>Mustilia gerontica</i> West	*	*	*	*	1	1	*	5	2	9
Saturniidae										
<i>Actias selene ningpoana</i> Felder & Felder	*	*	*	*	1	*	*	*	*	1
<i>Caligula thibeta okurai</i> Okano	*	*	*	*	*	*	*	1	*	1
<i>Caligula jonassii fukudai</i> Sonan	*	*	*	*	*	*	*	*	3	3
<i>Loepa megacore formosensis</i>	*	*	*	*	2	*	*	*	*	2
<i>Loepa miranda</i> Moore	*	*	*	*	5	*	*	*	*	5
Sphingoidea										
Sphingidae										
<i>Pentateucha curiosa</i> Swinhoe	1	*	*	*	*	*	*	*	*	1
<i>Acosmeryx naga</i> (Moore)	*	*	1	*	*	*	*	*	*	1
<i>Marumba cristata bukaiana</i> Clark	*	*	*	1	*	*	*	*	*	1

continued

Species	Feb.	Mar.	May	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
<i>Theretra nesus</i> (Drury)	*	*	*	*	2	*	*	*	*	2
<i>Cechenena lineosa lineosa</i> (Walker)	*	*	1	3	*	*	*	*	*	4
Noctuoidea										
Notodontidae										
<i>Acmeshachia gigante gigante</i> (Elwes)	*	*	*	*	*	*	5	*	*	5
<i>Benbowia takamukuana</i> (Matsumura)	*	*	*	*	*	*	1	*	*	1
<i>Damata formosicola</i> Matsumura	*	*	*	*	*	1	*	*	*	1
<i>Neodrymonia acuminata</i> (Matsumura)										
<i>Ginshachia gemmifera</i> (Moore)	*	*	*	*	*	1	*	*	*	1
<i>Hexafreum leucodera</i> (Staudinger)	*	*	*	*	*	2	*	*	*	2
<i>Hupodorta pulcherrima</i> (Moore)	*	*	*	*	*	2	*	*	*	2
<i>Microphalera yosimotoi</i> Kishida	*	*	*	*	*	1	*	*	*	1
<i>Netria viridescens</i> Walker	2	*	*	*	*	*	1	*	*	3
<i>Pantherinus bipunctatus</i> (Okano)	*	*	*	*	*	2	*	*	*	2
<i>Palaeostauropus obliterata</i>	*	*	*	*	*	*	8	4	*	12
<i>Pheosiopsis cinerea formosana</i> Okano	*	*	*	*	*	17	*	*	*	17
<i>Quadricalcarifera nigribasalis</i> Wileman	*	*	*	*	*	2	*	*	*	2
<i>Quadricalcarifera perdis</i> (Moore)	2	*	*	*	*	*	*	*	2	4
<i>Quadricalcarifera pryeri</i> (Leech)	*	*	*	*	*	4	*	*	*	4
<i>Quadricalcarifera viridimacula</i> Matsumura	1	*	*	*	*	*	*	*	*	1
<i>Quadricalcarifera subgeneris</i> (Strand)	*	*	*	4	*	*	*	*	*	4
<i>Rachia nodyna</i> (Swinhoe)	*	*	*	*	*	*	1	2	*	3
Lymantridae										
<i>Calliteara lunulata</i> (Matsumura)	*	*	*	*	*	2	1	*	*	3
<i>Lymantria</i> sp.	*	*	*	4	*	3	2	8	4	21
Arctiidae										
<i>Agylla divisa</i> Moore	*	*	*	*	8	*	*	2	*	10
<i>Chrysorabdia vilemani</i> Hampson	*	*	*	*	*	*	19	3	*	22
<i>Cyana formosana</i> (Hampson)	*	*	7	*	*	*	*	*	*	7
<i>Cyana subalba</i> Wileman	*	*	21	*	*	7	7	*	*	35
<i>Eilema magnata</i> Matsumura	*	*	*	*	4	4	*	*	*	8
<i>Eilema pulvereana</i> Wileman	*	*	*	*	9	*	*	*	*	9
<i>Eospilarctia lewisii</i> (Butler)	*	*	17	*	*	*	*	*	*	17

continued

Species	Feb.	Mar.	May	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
<i>Miltochrista fuscozonata</i> Inoue	*	*	4	*	*	*	*	*	*	4
<i>Miltochrista sauteri</i> Strand	*	*	21	*	1	*	*	*	*	22
<i>Nyctemera arctata</i> <i>albofasciata</i> Wileman	*	*	1	5	5	3	*	1	*	15
<i>Paraspilarctia magna</i> (Wileman)	*	*	5	*	*	*	*	*	*	5
<i>Palaeopsis</i> sp.	*	*	*	*	1	*	*	*	*	1
<i>Pelosia muscerda tetrastica</i> Hampson	*	*	*	*	*	8	*	*	*	8
<i>Spilarctia kikuchii</i> (Matsumura)	*	*	25	*	*	*	*	*	*	25
<i>Lemyra rhodophilodes</i> (Hampson)	*	*	26	*	*	6	*	*	*	32
<i>Lemyra stigmata</i> (Moore)	*	*	*	*	*	50	2	*	*	52
Noctuidae										
<i>Acronicta</i> sp.	*	*	*	*	*	*	*	*	7	7
<i>Agrapha acanthoplusia</i> <i>adiaphora</i> Dufuy	*	*	*	1	*	*	*	*	*	1
<i>Anomis</i> sp.	*	*	*	*	*	*	*	1	*	1
<i>Colyptra</i> sp.	*	*	*	*	2	*	*	*	*	2
<i>Cucullia fraterna</i> Butler	*	*	*	*	*	1	1	1	*	3
<i>Daddala lucilla</i> (Butler)	*	*	1	*	*	2	*	*	*	3
<i>Daseochaeta autumnalis</i> Chang	*	*	*	*	*	*	12	13	*	25
<i>Diphtherocome pulchra</i> (Wileman)	*	*	*	*	1	3	7	7	*	18
<i>Earias</i> sp.1	*	*	*	1	*	*	2	5	*	8
<i>Earias</i> sp.2	*	*	*	*	*	*	*	1	*	1
<i>Ercheia umbrosa</i> Butler	*	*	*	*	1	*	*	*	*	1
<i>Hypersynpoides</i> sp.	*	*	2	1	2	10	2	*	*	17
<i>Hypocala deflorata</i> (Fabricius)	*	*	*	*	*	*	15	*	*	15
<i>Mamestra brassicae</i> (L.)	*	*	2	1	2	10	3	*	12	30
<i>Nola pallescens</i> Wileman & West	*	*	*	*	*	*	*	3	*	3
<i>Nola</i> sp.	*	*	1	*	*	2	*	1	*	4
<i>Phlogophora albovittata</i> (Moore)	*	*	*	1	*	*	*	1	1	3
<i>Sineugraphe rhytidoprocta</i> Boursin	*	*	*	*	*	*	16	3	*	19
<i>Synpoides</i> sp.	*	*	*	*	2	7	3	*	*	12
<i>Tiracola aureata</i> Holloway	*	*	3	*	*	*	*	*	1	4
<i>Trachea</i> sp.	*	*	1	*	*	*	*	*	*	1
<i>Xanthia</i> sp.	*	*	*	*	*	6	*	*	*	6

Table 3. Moth catch data from 1991 light-trapping in the temperate forest at Meifeng, Nantou, Taiwan.

Species	Jan.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Total
Drepanoidea										
Drepanidae										
<i>Macrocilix mysticata flavotincta</i> Inoue	*	*	*	2	2	1	*	*	*	5
<i>Nordstroemia lilacina</i> (Moore)	*	*	*	5	*	1	*	*	*	6
<i>Oreta brunnea</i> Wileman	1	*	1	*	1	7	8	3	2	23
<i>Oreta extensa</i> Walker	*	*	*	*	*	1	*	*	1	2
Thyatiridae										
<i>Tethea watanabei</i> (Matsumura)	*	*	1	1	*	*	*	*	*	2
Geometridae										
<i>Abraxas cupreilluminata</i> Inoue	*	*	1	*	*	8	5	8	*	22
<i>Abraxas fletcheri</i> Inoue	*	*	*	*	*	*	*	*	34	34
<i>Abraxas suspecta</i> Warren	*	*	*	*	*	*	*	*	2	2
<i>Abraxas taiwanensis</i> Inoue	*	*	1	1	*	*	3	4	2	11
<i>Abraxas tenuisuffusa</i> Inoue	1	*	*	8	*	*	*	*	*	9
<i>Agathia magnificentia</i> Inoue	*	3	*	2	14	3	*	*	*	22
<i>Alcis admissaria undulacia</i> Wileman	*	*	1	*	*	*	2	*	*	3
<i>Alcis variegata subochrearia</i> (Wileman & South)	*	1	*	7	*	*	2	*	1	11
<i>Arichanna albomaculata</i> Leech	*	1	*	*	14	*	*	*	*	15
<i>Arichanna amoena</i> Bastelberger	*	11	19	*	7	*	*	*	1	38
<i>Arichanna fumigata</i> (Bastelberger)	2	15	*	35	10	8	1	1	*	72
<i>Cassyma deletaria</i> (Moore)	*	2	1	*	8	*	*	1	*	12
<i>Chlorodontopera discopilata</i> (Moore)	*	*	*	*	*	*	*	*	1	1
<i>Cleora fraterna</i> (Moore)	1	*	*	*	*	*	*	*	*	1
<i>Cassyma deletaria</i> (Moore)	*	2	*	*	*	3	*	*	*	5
<i>Comibaena pictipennis</i> Butler	*	1	*	*	*	*	*	*	*	1
<i>Crypsicometa homoema</i> Prout	*	*	*	*	*	2	*	*	*	2
<i>Dilophodes pavidus</i> Bastelberger	1	*	*	*	*	*	*	*	*	1
<i>Dindica taiwana</i> Wileman	*	*	*	*	*	1	1	*	*	2
<i>Diplurodes vestitus fusvovestitus</i> Inoue	*	*	*	*	22	*	*	*	*	22
<i>Dysstroma calamistratum</i> <i>scalatum</i> Bastelberger	*	*	*	*	*	*	*	1	*	1
<i>Dysstroma cinereatum</i> (Moore)	*	2	*	*	*	*	*	1	*	3
<i>Dysstroma</i> sp.	*	*	*	*	1	13	*	1	2	17
<i>Ecliptopera muscicolor</i> <i>allobathra</i> Prout	*	1	*	*	2	1	*	*	*	4
<i>Ecliptopera recordans</i> Prout	*	*	*	*	15	*	*	*	*	15
<i>Ecliptopera</i> sp.	*	1	1	*	*	4	*	*	*	6

continued

Species	Jan.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Total
<i>Ectropis</i> sp.	12	2	*	*	*	*	*	*	*	14
<i>Erebomorpha fulguraria</i> Walker	*	1	*	1	4	4	2	2	1	15
<i>Eulithis subalba</i> (Prout)	*	*	*	*	10	1	*	*	*	11
<i>Eustroma contortum</i> (Warren)	*	*	*	*	2	2	*	*	*	4
<i>Eustroma melancholicum interruptum</i> (Wileman)	*	4	*	*	4	3	*	*	*	11
<i>Eustroma</i> sp.1	*	*	*	*	*	*	*	*	1	1
<i>Eustroma</i> sp.2	*	*	4	*	1	3	*	*	*	8
<i>Eustroma</i> sp.3	*	3	*	*	*	*	*	*	*	3
<i>Eustroma</i> sp.4	*	1	*	*	*	*	*	*	*	1
<i>Garaeus specularis</i> Moore	*	6	*	*	*	*	*	*	*	6
<i>Gastrocome pannosaria orta</i> (Bastelberger)	*	4	1	9	*	8	4	*	3	29
<i>Gelasma</i> sp.	*	*	1	*	3	*	*	*	*	4
<i>Heterolocha biplagiata</i> Basterberger	*	1	*	*	2	2	*	*	*	5
<i>Heterolocha</i> sp.	*	1	*	*	*	*	*	*	*	1
<i>Hypochrosis rufescens</i> Butler	1	*	2	*	*	*	1	*	*	4
<i>Hypomecis roboraria amplaria</i> (Wileman)	1	*	2	*	*	*	*	*	1	4
<i>Hypomecis</i> sp.	1	5	*	*	*	4	2	1	*	13
<i>Krananda semihyalina</i> Moore	1	*	*	*	*	*	*	*	1	2
<i>Lobogonia</i> sp.	*	2	4	6	14	8	4	*	*	38
<i>Lomographa platyleucata marginata</i> (Wileman)	*	11	2	22	5	39	3	3	7	92
<i>Loxaspilates arrizanaria</i> Bastelberger	*	21	1	*	*	*	*	*	1	23
<i>Medasina infausta</i> Prout	*	*	1	*	*	*	*	*	*	1
<i>Medasina</i> sp.	*	*	1	*	20	*	2	1	2	26
<i>Melanthia procellata szechuanensis</i> (Wehrli)	*	1	*	*	12	*	12	1	2	28
<i>Menophra anaplagiata</i> Sato	1	*	*	*	9	10	1	*	*	21
<i>Menophra humeraria</i> (Moore)	*	1	*	*	*	*	*	*	*	1
<i>Menophra</i> sp.	*	23	*	*	9	13	1	*	*	46
<i>Micronidia intermedia</i> Yazaki	*	3	*	2	6	7	2	*	*	20
<i>Myrteta sericea</i> (Butler)	*	*	*	5	2	3	*	*	*	10
<i>Myrteta</i> sp.	*	*	*	2	*	*	*	*	*	2
<i>Nothomiza flavicosta</i> Prout	*	2	*	3	3	*	1	*	1	10
<i>Obeidia gigantearia marginifascia</i> Prout	*	*	*	*	2	7	1	*	*	10
<i>Odontopera albigitulata</i> Bastelberger	*	*	*	*	*	4	6	*	6	16
<i>Odontopera insulata</i> Bastelberger	5	*	*	*	*	*	*	*	*	5
<i>Odontopera bilinearia</i> subarida Inoue	*	*	*	*	*	*	*	3	*	3
<i>Opisthograptis punctilineata</i> Wileman	*	*	*	1	*	*	*	*	*	1
<i>Ourapteryx caecata</i>	*	*	*	18	9	*	*	1	*	28

continued

Species	Jan.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Total
(Bastelberger)										
<i>Ourapteryx clara formosana</i> Matsumura	*	1	*	*	*	*	1	*	*	2
<i>Ourapteryx similaria horishana</i> (Matsumura)	*	*	*	*	11	*	*	*	*	11
<i>Ourapteryx virescens</i> Matsumura	*	*	*	1	*	*	*	*	*	1
<i>Percnia</i> sp.2	1	*	2	*	*	*	*	*	*	3
<i>Percnia</i> sp.3	*	*	*	*	*	*	3	*	*	3
<i>Photoscotosia atrostrigata</i> (Bremer)	*	*	*	*	*	*	*	*	6	6
<i>Photoscotosia miniosata</i> (Walker)	*	3	1	*	*	*	*	*	*	4
<i>Psyra conferta</i> Inoue	*	15	14	18	23	10	8	1	*	89
<i>Psyra cuneata</i> matsumurai Bastelberger	*	*	4	6	9	5	*	1	*	25
<i>Sibatania arizana</i> (Wileman)	*	*	1	12	2	*	1	*	*	16
<i>Synegiodes histrionarius ornatus</i> (Bastelberger)	*	8	4	*	*	5	4	*	*	21
<i>Tanaoctenia halitaria</i> (Walker)	*	21	5	17	3	7	10	2	*	65
<i>Tanaorhinus</i> sp.	*	*	*	*	*	2	*	*	*	2
<i>Trichopterigia</i> sp.	1	*	*	*	*	*	*	*	*	1
Bombycoidea										
Lasiocampidae										
<i>Kunugia undans metanastroides</i> (Strand)	2	*	*	*	*	*	*	10	7	19
<i>Dendrolimus punctatus</i> (Walker)	*	*	1	2	*	*	*	3	*	6
Eupterotidae										
<i>Palirisa cervina formosana</i> Matsumura	*	*	2	16	*	*	*	*	*	18
Bombycidae										
<i>Mustilia gerontica</i> West	*	*	*	*	*	1	*	*	*	1
Sphingoidea										
Sphingidae										
<i>Agris convolvuli</i> (Linn.)	*	*	*	*	*	1	1	*	*	2
<i>Pentateucha curiosa</i> Swinhoe	*	17	*	*	*	*	*	*	*	17
<i>Marumba cristata bukaiana</i> Clark	*	*	*	*	1	1	*	*	*	2
Noctuoidea										
Notodontidae										
<i>Benbowia takamukuana</i> (Matsumura)	*	*	*	*	*	1	1	*	*	2

continued

Species	Jan.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Total
<i>Daddala lucilla</i> (Butler)	*	*	*	*	1	*	*	*	*	1
<i>Daseochaeta autumnalis</i> Chang	*	*	*	*	*	*	*	*	3	3
<i>Diphtherocome pulchra</i> (Wileman)	*	*	*	*	2	*	*	1	*	3
<i>Dictyestra dissecta</i> (Walker)	*	*	*	*	2	*	*	1	*	3
<i>Earias</i> sp.	*	*	*	*	*	*	*	*	1	1
<i>Eracheia umbrosa</i> Butler	*	*	*	1	*	*	*	1	*	2
<i>Hypersynoides</i> sp.	1	36	*	6	13	2	2	*	*	60
<i>Mamestra brassicae</i> (L.)	*	*	*	*	14	*	1	*	1	16
<i>Nola</i> sp.	*	*	*	*	1	*	*	*	*	1
<i>Phlogophora conservuloides</i> (Hampson)	*	1	*	*	*	*	*	*	*	1
<i>Synoides</i> sp.1	*	*	*	*	*	1	*	*	*	1
<i>Synoides</i> sp.2	*	2	5	7	5	1	2	1	*	23

2. Relative abundance of moth community

The moth data were obtained from a temperate forest at Meifeng, Nantou County by combining the catches from monthly surveys in 1990 and 1991 (see Tables 2 and 3). The frequency distribution of specimens per collected species is given for each year in Appendix 3. The goodness-of-fit test for the log-normal model of observed frequency data arranged in octaves is presented in Appendices 4 and 5. the frequency distribution of abundance is best fitted by log-normal relationship.

The structure of a community is affected by relationships between species and by their relative abundance. The relative abundance of individuals in particular species may have a marked influence on the nature and functioning of the community as a whole, and the distribution of individuals between species within community may affect on the stability of the community. The logarithmic patterns of abundance may indicate a small community with strong, uneven competition for resources, while a log-normal distribution suggests a complex, heterogeneous assemblage ordered by many ecological pressures in conjunction (Putman & Wratten, 1984). Minshall et al. (1985) used the log-normal model as an empirical measure of the

equilibrium state of invertebrate communities in river ecosystems. They suggested that a high degree of conformance with the log-normal model indicates a community in a high degree of equilibrium. Thus an evaluation of conformity to log-normal distribution across seasons could be used as a measure of the equilibrium state of the system.

3. Diversity indices

Species diversity indices for moths surveyed in the temperate forest of Meifeng in 1990 and 1991 and the monthly variation in the Margalef index (R1), Menhinick index (R2), Shannon index (H'), Evenness index (E1) and (E2) are presented in Appendices 6 and 7.

Appendices 6 and 7 suggest that the number of species in a community is variable. This can be affected by the sample size and the duration of light in the light trap. Two richness indices (R1 and R2) which are independent of sample size are used in this study for comparison between months. Three months (November 1990, May 1991 and July 1991) show rather high species richness. In general, species richness of the moth community in 1991 was higher than in 1990. This is probably due to the different

Table 4. Moth catch from 1990-1991 light trapping in primary temperate forest at Meifeng, Nantou, Taiwan.

Species	1990	1991	1990 + 1991
Drepanoidea			
Drepanidae			
<i>Canucha miranda</i>	1	*	1
<i>formosicola</i> Matsumura			
<i>Macrocilix mysticata flavotincta</i> Inoue	*	5	5
<i>Macrauzata minor</i> Okano	8	*	8
<i>Nordstroemia lilacina</i> (Moore)	2	6	8
<i>Oreta brunnea</i> Wileman	41	23	64
<i>Oreta extensa</i> Walker	17	2	19
Cyclidiidae			
<i>Cyclidia substigmata</i> (Hubner)	1	*	1
Thyatiridae			
<i>Tethea watanabei</i> (Matsumura)	2	2	4
Geometroidea			
Geometridae			
<i>Abraxas cupreillumina</i> Inoue	*	22	22
<i>Abraxas fletcheri</i> Inoue	*	34	34
<i>Abraxas suspecta</i> Warren	17	2	19
<i>Abraxas taiwanensis</i> Inoue	6	11	17
<i>Abraxas tenuisuffusa</i> Inoue	4	9	13
<i>Abraxas</i> sp	8	*	8
<i>Agathia magnificentia</i> Inoue	*	22	22
<i>Alcis admissaria undulacia</i> Wileman	24	3	27
<i>Alcis plebeia</i> Wileman	20	*	29
<i>Alcis variegata subochrearia</i> (Wileman & South)	19	11	30
<i>Arichanna albomaculata</i> Leech	*	15	15
<i>Arichanna amoena</i> Bastelberger	2	38	40
<i>Arichanna fumigata</i> (Bastelberger)	28	72	100
<i>Arichanna</i> sp.1	21	*	21
<i>Arichanna</i> sp.2	2	*	2
<i>Cassyma deletaria</i> (Moore)	2	17	19
<i>Cassyma</i> sp.	1	*	1
<i>Chlorodontopera discopilata</i> (Moore)	*	1	1
<i>Cleora fraterna</i> (Moore)	*	1	1
<i>Comibaena pictipennis</i> Butler	*	1	1
<i>Crypsicometa homoema</i> Prout	*	2	2
<i>Dilophodes pavidus</i>	*	1	1

continued

Species	1990	1991	1990 + 1991
Bastelberger			
<i>Dindica taiwana</i> Wileman	*	2	2
<i>Diplurodes vestitus fusvovestitus</i>	6	22	28
Inoue			
<i>Dysstroma calamistratum</i>	2	1	3
<i>scalatum</i> Bastelberger			
<i>Dysstroma cinereatum</i> (Moore)	3	3	6
<i>Dysstroma</i> sp.	2	17	19
<i>Ecliptopera muscicolor</i>	18	4	22
<i>allobathra</i> Prout			
<i>Ecliptopera recordans</i> Prout	3	15	18
<i>Ecliptopera</i> sp.	*	6	6
<i>Ectropis</i> sp.	*	14	14
<i>Electrophaes taiwana</i> Inoue	3	*	3
<i>Erebomorpha fulguraria</i> Walker	3	15	18
<i>Eulithis subalba</i> (Prout)	*	11	11
<i>Eustroma contortum</i> (Warren)	*	4	4
<i>Eustroma melancholicum</i>	*	11	11
<i>interruptum</i> (Wileman)			
<i>Eustroma</i> sp.1	3	1	4
<i>Eustroma</i> sp.2	*	8	8
<i>Eustroma</i> sp.3	*	3	3
<i>Eustroma</i> sp.4	*	1	1
<i>Garaeus specularis</i> Moore	*	6	6
<i>Gastrocome pannosaria</i>	1	29	30
<i>orta</i> (Bastelberger)	1	29	30
<i>Gelasma</i> sp.	*	4	4
<i>Heterolocha biplagiata</i>	2	5	7
Basterberger			
<i>Heterolocha</i> sp.	2	1	3
<i>Hydrelia enisaria</i> Prout	9	*	9
<i>Hypochrosis rufescens</i>	*	4	4
<i>Hypomecis roboraria</i>	1	4	5
<i>amplaria</i> (Wileman)			
<i>Hypomecis</i> sp.	1	13	14
<i>Krananda semihyalina</i> Moore	7	2	9
<i>Lobogonia</i> sp.	1	38	39
<i>Lomographa platyleucata marginata</i>	27	92	119
(Wileman)			
<i>Loxaspilates arrizanaria</i>	*	23	23
Bastelberger			
<i>Medasina infausta</i> Prout	1	1	2
<i>Medasina paralbidaria</i> Inoue	6	*	6
<i>Medasina</i> sp.	*	26	26
<i>Melanthia catenaria mesozona</i>	7	*	7
Prout			
<i>Melanthia procellata</i>	*	28	28
<i>szechuanensis</i> (Wehrli)			

continued

Species	1990	1991	1990 + 1991
<i>Menophra anaplagiata</i> Sato	3	21	24
<i>Menophra humeraria</i> (Moore)	2	1	3
<i>Menophra</i> sp.	10	46	56
<i>Metabraxas rubrotincta</i> Inoue	6	*	6
<i>Micronidia intermedia</i> Yazaki	3	20	23
<i>Myrteta sericea</i> (Butler)	4	10	14
<i>Myrteta</i> sp.	138	2	140
<i>Nothomiza flavicosta</i> Prout	*	10	10
<i>Obeidia gigantearia marginifascia</i> Prout	*	10	10
<i>Odontopera albiguttulata</i> Bastelberger	10	16	26
<i>Odontopera insulata</i> Bastelberger	*	5	5
<i>Odontopera bilinearia subarida</i> Inoue	4	3	7
<i>Opisthograptis punctilineata</i> Wileman	4	1	5
<i>Ourapteryx caecata</i> (Bastelberger)	19	28	47
<i>Ourapteryx clara formosana</i> Matsumura	3	2	5
<i>Ourapteryx similaria horishana</i> (Matsumura)	1	11	12
<i>Ourapteryx virescens</i> Matsumura	3	1	4
<i>Ourapteryx</i> sp.1	8	*	8
<i>Ourapteryx</i> sp.2	8	*	8
<i>Paradarisa</i> sp.	9	*	9
<i>Percnia</i> sp.1	2	*	2
<i>Percnia</i> sp.2	*	3	3
<i>Percnia</i> sp.3	*	3	3
<i>Photoscotosia atrostrigata</i> (Bremer)	2	6	8
<i>Photoscotosia insularis</i> Bastelberger	2	*	2
<i>Photoscotosia miniosata</i> (Walker)	4	4	8
<i>Photoscotosia</i> sp.1	3	*	3
<i>Photoscotosia</i> sp.2	4	*	4
<i>Photoscotosia</i> sp.3	5	*	5
<i>Protonebula altera</i> (Bastelberger)	1	*	1
<i>Psyra conferta</i> Inoue	6	89	95
<i>Psyra cuneata matsumurai</i> Bastelberger	1	25	26
<i>Sibatania azizana</i> (Wileman)	2	16	18
<i>Synegiodes histrionarius ornatus</i> (Bastelberger)	*	21	21

continued

Species	1990	1991	1990 + 1991
<i>Tanaoctenia haliaria</i> (Walker)	12	65	77
<i>Tanaorhinus</i> sp.	*	2	2
<i>Timandra</i> sp.	69	*	69
<i>Trichopterigia</i> sp.	1	1	2
<hr/>			
Bombycoidea			
Lasiocampidae			
<i>Kunugia undans metanastroides</i> (Strand)	6	19	25
<i>Dendrolimus punctatus</i> (Walker)	2	6	8
<i>Syrastrena sumatrana</i> Tams	1	*	1
<hr/>			
Eupterotidae			
<i>Palirisa cervina formosana</i> Matsumura	62	18	80
<hr/>			
Bombycidae			
<i>Mustilia gerontica</i> West	9	1	10
<hr/>			
Saturniidae			
<i>Actias selene ningpoana</i> Felder & Felder	1	*	1
<i>Caligula thibeta okurai</i> Okano	1	*	1
<i>Caligula jonasii fukudai</i> Sonan	3	*	3
<i>Loepa megacore formosensis</i> Mell	2	*	2
<i>Loepa miranda</i> Moore	5	*	5
<hr/>			
Sphingoidea			
Sphingidae			
<i>Agris convolvuli</i> (Linn.)	*	2	2
<i>Pentateucha curiosa</i> Swinhoe	1	17	18
<i>Acosmeryx naga</i> (Moore)	1	*	1
<i>Marumba cristata bukaina</i> Clark	1	2	3
<i>Theretra nessus</i> (Drury)	2	*	2
<i>Cechenena lineosa lineosa</i> (Walker)	4	*	4
<hr/>			
Noctuoidea			
Notodontidae			
<i>Acmeshachia gigante</i> (Elwes)	5	*	5
<i>Benbowia takamukuana</i> (Matsumura)	1	2	3
<i>Damata formosicola</i> Matsumura	1	*	1
<i>Ginshachia gemmifera</i> (Moore)	1	2	3

continued

Species	1990	1991	1990 + 1991
<i>Hexafrenum leucodera</i> (Staudinger)	2	*	2
<i>Hexafrenum maculifer</i> Matsumura	*	9	9
<i>Hupodonta pulcherrima</i> (Moore)	2	3	5
<i>Neodrymonia acuminata</i> (Matsumura)	*	2	2
<i>Netria viridescens</i> Walker	3	*	3
<i>Pantherinus bipunctatus</i> (Okano)	2	4	6
<i>Pheosiopsis cinerea formosana</i> (Okano)	17	7	24
<i>Quadricalcarifera nigribasalis</i> Wileman	2	*	2
<i>Quadricalcarifera perdix</i> (Moore)	4	14	18
<i>Quadricalcarifera pryeri</i> (Leech)	4	1	5
<i>Quadricalcarifera viridimaculata</i> Matsumura	1	1	2
<i>Rachia nodyna</i> (Swinhoe)	3	1	4
<i>Somera viridifusca</i> Walker	*	3	3
Lymantridae			
<i>Calliteara lunulata takamukuana</i> (Matsumura)	3	1	4
<i>Euproctis</i> sp.	*	8	8
<i>Lymantria</i> sp.1	21	19	40
<i>Lymantria</i> sp.2	*	4	4
Arctiidae			
<i>Agylla divisa</i> Moore	10	4	14
<i>Agylla virago</i> Rothschild	*	2	2
<i>Chrysoabdia vilemani</i> Hampson	22	4	26
<i>Cyana formosana</i> (Hampson)	7	3	10
<i>Cyana hamata</i> Walker	*	2	2
<i>Cyana propinqua</i> (Wileman)	*	4	4
<i>Cyana subalba</i> Waleman	35	2	37
<i>Eilema magnata</i> Matsumura	8	*	8
<i>Eilema pulverea</i> Wileman	9	*	9
<i>Eilema tecta</i> Wileman	*	2	2
<i>Eospilarctia lewisii</i> (Butler)	17	36	53
<i>Eospilarctia nehallenia</i> <i>baibarensis</i> (Matsumura)	*	19	19
<i>Lemyra alikangensis</i> (Strand)	*	3	3
<i>Lemyra rhodophilodes</i> (Hampson)	32	13	45
<i>Lemyra stigmata</i> (Moore)	52	*	52
<i>Miltochrista fuscozonata</i> Inoue	4	*	4
<i>Miltochrista sauteri</i> Strand	22	38	60
<i>Nyctemera arctata</i> Wileman	15	1	16
<i>Paraspilarctia magna</i> (Wileman)	5	10	15
<i>Palaeopsis</i> sp.	1	*	1
<i>Pelosia muscerda tetrastica</i> Hampson	8	*	8
<i>Spilarctia kikuchii</i> (Matsumura)	25	*	25

continued

Species	1990	1991	1990 + 1991
Noctuidae			
<i>Acronicta</i> sp.	7	*	7
<i>Agrapha acanthoplusia</i> <i>adiaphora</i> Dufuy	1	*	1
<i>Amphipyra</i> sp.	*	2	2
<i>Anomis</i> sp.	1	*	1
<i>Arcte coerulea</i> (Guenee)	*	1	1
<i>Asota heliconia zebrina</i> (Butler)	*	15	15
<i>Atacira</i> sp.	*	2	2
<i>Clavipalpula aurariae</i> (Oberthur)	*	2	2
<i>Colyptra</i> sp.	2	*	2
<i>Cucullia fraterna</i> Butler	3	2	5
<i>Daddala lucilla</i> (Butler)	3	1	4
<i>Daseochaeta autumnalis</i> Chang	25	3	28
<i>Diphtherocome pulchra</i> (Wileman)	18	3	21
<i>Dictyestra dissecta</i> (Walker)	*	3	3
<i>Earias</i> sp.1	8	*	8
<i>Earias</i> sp.2	1	1	2
<i>Eracheia umbrosa</i> Butler	1	2	3
<i>Hypersynoides</i> sp.	17	60	77
<i>Hypocala deflorata</i> (Fabricius)	15	*	15
<i>Mamestra brassicae</i> (L.)	30	16	46
<i>Nola pallescens</i> Wileman & West	3	*	3
<i>Nola</i> sp.	3	1	4
<i>Phlogophora albovittata</i> (Moore)	3	*	3
<i>Phlogophora conservuloides</i> (Hampson)	*	1	1
<i>Sineugraphe rhytidoprocta</i> Boursin	19	*	19
<i>Synoides</i> sp.1	*	1	1
<i>Synoides</i> sp.2	12	23	35
<i>Tiracola aureata</i> Holloway	4	*	4
<i>Trachea</i> sp.	1	*	1
<i>Xanthia</i> sp.	6	*	6
Total moth	1335	1565	2900
Total species	146	144	200

Sorensens's indices of similarity for taxonomic comparison of two years' moth data is 0.5896

sampling locations with different habitats. Appendix 1 suggests that the variation of diversity of moth community in 1991 is rather small, relative to that in 1990. Appendix 2 corroborates this result.

Diversity can be measured either at the community (habitat) or the species level. In this study, it was considered at the species level. The diversity of species can be estimated in at least three different ways. First, diversity can refer to the species richness at the site, the number of known species. Second, it can be defined as a function of the number of species and their relative abundance (measured by numbers of individuals, or their total biomass). Third, diversity can relate to the number of trophic levels and the interconnections between the species both within and between trophic levels (Goodman, 1975). Usher (1986) mentioned that there is a tendency for increased number of species as the sample size increases, so that species diversity can only be compared among equal-sized samples. Diversity and its measurement have long been a topic of discussion in the ecological literature. Morris and Lakhani (1979) found the Shannon-Weaver index to be more sensitive to differences between sites than the Simpson index. It may also be more sensitive to difference between seasons.

Margules (1986) suggested that diversity should be the focus of conservation decisions, but that diversity at a particular site should not be used alone to judge conservation value. Biological diversity varies from place to place, depending on a complex set of environmental variables and interactions between them. Diversity provides no basis for comparison except between sites of the same habitat type.

4. Seasonal changes in insect diversity

Moth faunal lists and monthly occurrence are showed in Tables 2 and 3. The total number of individual moths collected was 1335 in 1990 and 1565 in 1991. Monthly variation in the abundance of various species of moths in a light trap at Meifeng, Nantou is showed in Figure 2 and Appendices 6 and 7, in which summer (June-August) appears as the most moth-abundant time of year.

In 1990, the number of species increased in May, in September, and in November, and declined in other months. In 1991 the seasonal pattern was different, in which the number of species increased

in May, June, and July and slowly declined in other months. The species abundance was evenly distributed in 1991 but not in 1990, with rather high evenness index in May.

5. Correlation between moth numbers and weather factors

The relationships between species diversity and environmental factors are presented in Figure 2 and Appendices 8 and 9. There is a significant correlation between number of moths and rainfall ($r=0.5634$), and between number of moths and mean temperature (0.8035). The variation in species diversity is correlated with climatic factors, especially temperature and rainfall, which may influence population fluctuations in the temperate forest.

The foliage of many tree species change in quality during the summer. Correlated with these changes is the species composition and abundance of leaf-feeding larvae (Lawton, 1978).

Correlation analysis can be used to assessing which environmental variables best explain the species's abundance and which appear unimportant. Once the relations between species and environmental variables have been quantified, they can predict species abundance from observed environmental values or, conversely, environmental variables can be predicted from observed species abundances.

6. Larval host plants

Larval host plants of *Arichanna* spp. are Ericaceae (*Rhododendron* sp. which is abundant in middle and high altitude mountain area). Larval host plants of *Myrteta* spp are Theaceae (*Eurya* sp. and *Schima* sp.). Larval host plants of *Abraxas* included Salicaceae (*Populus* sp., *Salix* sp.), Aceraceae (*Acer* sp.), Ulmaceae (*Ulmus* sp., *Zelkova* sp.). Larval host plants of *Ourapteryx* sp. and *Psyra* spp. include Fagaceae (*Quercus* sp.) (Inoue et al., 1982; Chang & Hung, 1986; Sugi, 1987; and Chang et al., 1992).

Lepidoptera often show great specificity in larval food plant from a long history of coevolution and adaptation to diverse mechanisms of chemical and physical defense in the plants (Holloway, 1980).

Holloway & Herbert (1979) reported that the degree of larval specificity varies from family to

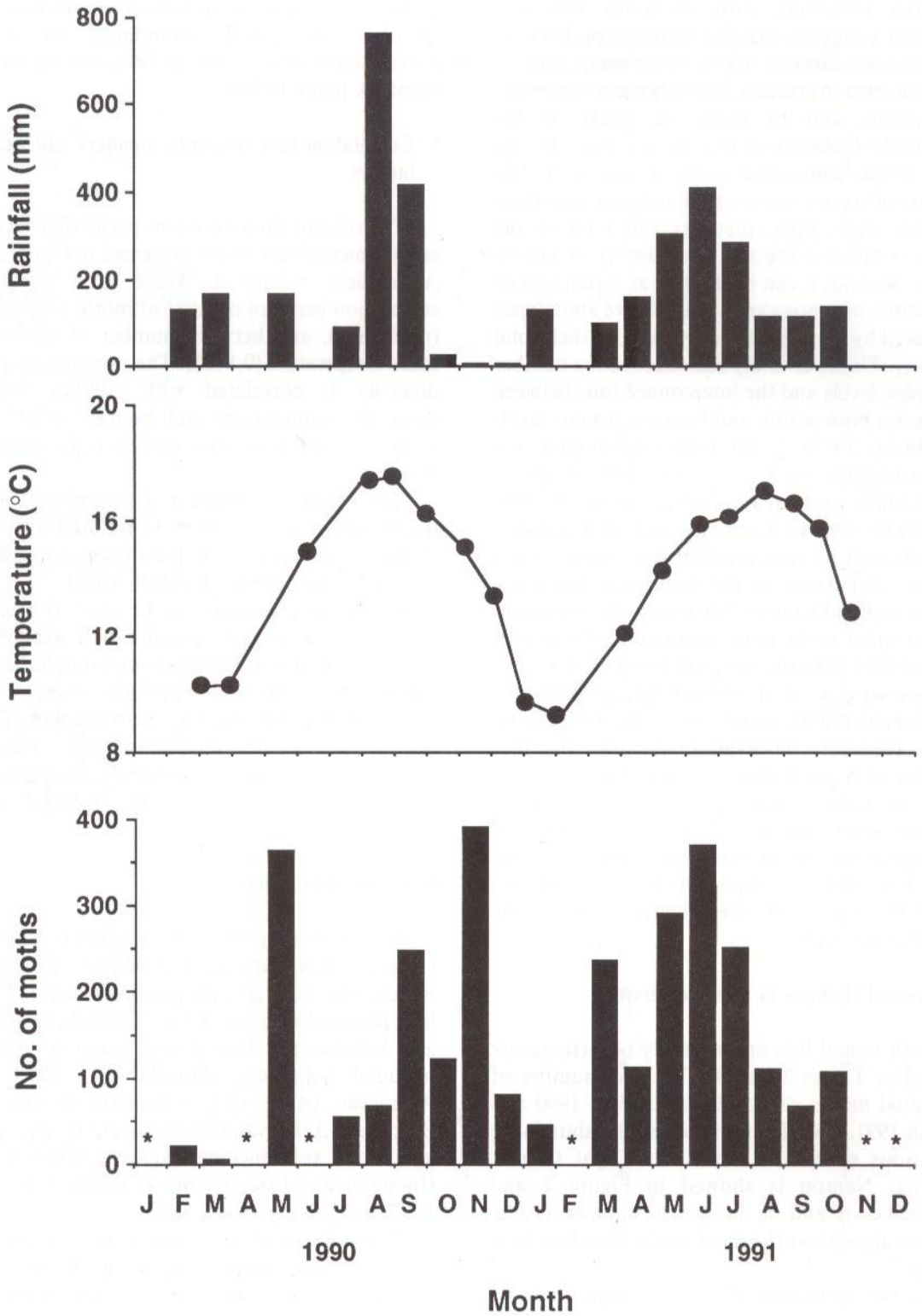


Figure 2. Relationships among number of moths trapped and monthly rainfall, and temperature in 1990-1991 at Meifeng, Nantou. * represents no data collected.

family. They also noted that among the notodontids, citheroniids, drepanids, thyatirids and noctuids less than half the species were polyphagous, nearly two-thirds of the geometrids and nine-tenths of the species in the remaining families were polyphagous in an analysis of Canadian Forest Insect Survey food records. About 40% of the macroheteroceran species feeding on Canadian forest trees are monophagous at the family level, and nearly 20% feed on a single genus. About 39% of the moth species are polyphagous, with variation among the different families and genera. The majority of these species feed solely on angiosperms. There were significantly higher number of the ennomine than harentiine geometrids. Among the four noctuid subfamilies, nearly 90% of the hadenines but less than 10% of the catocalines were polyphagous. Holloway & herbert (1979) also mentioned that such familial differences in the incidence of polyphagy are not restricted to Canada.

Certain Lepidoptera appear to be restricted to the forest understory (e.g. species of Eupterotidae), whereas in others a majority fly primarily at canopy level (e.g. Geometridae) (Holloway, 1980). Lepidoptera are often very habitat-specific and could presumably provide useful indicators of environmental quality, but there is no obvious correlation between floristic diversity in a given biotope and the diversity of the associated Lepidoptera (Holloway, 1980).

An understanding of the associations of various species of insects with a particular plant will requires approaches at several levels, geographic, ecological, even physiological and behavioral. Lawton (1978) suggested that plants with large geographical ranges support more species of insects than do rare plants, as they are more likely to be found and colonized in time (Lawton & Schroder, 1977). The pattern of increasing species diversity with season is a direct consequence of changes in the structure and chemical composition of the plant. The possibility that plant structure may influence insect diversity derive from phytophagous insects competing in the classificational manner for a limited food supply, the number of species on a plant being determined by niche overlap and niche width along resources axes represented by the various parts of the plant, such as leaves, stems and fruits (Lawton, 1978).

Murdoch et al. (1972) found that plant species diversity and vegetation-complexity (foliage height

diversity) are almost equally good predictors of insect species diversity.

8. Conservation and monitoring

Many species of Lepidoptera have specialized habitat requirement and very localized distribution (Holloway & Herbert, 1979). Habitat destruction can have a serious impact on their populations. When the habitats of such species are destroyed, we can expect the moths also to disappear unless they can adapt to other habitats. Habitat degradation has become widespread in Taiwan in recent years. Previously undisturbed lands are now under heavy pressure for conversion to meet needs. Concerning about the future of the island's flora and fauna, must therefore concentrate on those species that may have specialized habitat requirements. In evaluating the conservation status of the Lepidoptera in Taiwan, we must continue similar types of survey and investigate the impact of habitat destruction on populations, focusing on the ecology of individual species. Larval food-plant and other biological studies are also very important.

In recent years, the idea of using indicator groups for the monitoring of terrestrial environments has increasingly gained favor (Holloway, 1983; Wiederholm, 1980). Holloway (1981) summarized the problems of terrestrial monitoring, noted that terrestrial environments are subject to greater fluctuations in such variables as temperature, light intensity and niche diversity. In monitoring changes in either environment, the goal of determining the timing of changes remains the same.

Moths as an indicator group of terrestrial stability have several valuable features: 1) virtually all are phytophagous; 2) their attraction to light provides a simple way to monitor changes in all niches of an area, making moth diversity as a sufficient index of environmental stability; and 3) Lepidoptera are widely dispersed among plant hosts, and are relatively sensitive to environmental change, since many of the species are host specific. when at least a few annual sequences of weekly or monthly sampling have provide baseline data on normal fluctuations in species numbers, and when populations are better known for an area, a monitoring program should be able to use moth diversity changes as an indication of environmental change (Sutton & Hudson, 1980).

A well-known taxonomic group like Lepidoptera, readily sampled through light traps for the moth component, and widely dispersed among plant species and niches of an area, is one of the best terrestrial groups for ecological monitoring. Since the general habitat is monitored, through plant-feeding insects, the conservation status of an area should be evident over time. (Holloway, 1980; Heppner, 1989)

CONCLUSION

Monthly surveys were conducted at Meifeng, Nantou in 1990 and 1991. A total of 200 macroheteroceran species were recorded, most of them geometrids and noctuids. The most dominant genera are *Arichanna*, *Myrtera*, *Lomograph*, *Psyra*, *Abraxa*, *Ourapteryx*, *Menophra*, *Rimandra*, *Oreta*, *Thanatarctia*, *Miltochrista*, *Eospilarctia*, *Cyana*, and *Agylla*. The very rare and little known sphingid *Pentateucha curiosa* Swinhoe was founded in this area during February and March.

The distribution of species abundance in the Meifeng area fits by a log-normal curve and suggests a complex and heterogeneous assemblage ordered by a large number of ecological pressures in conjunction. A high degree of conformance with the log-normal model indicates a community in high degree of equilibrium.

A large fraction of species are represented in the samples by very few individuals, and only a few species are abundantly represented. Since some of the moths are highly host specific, they may cause species damage in several tree species. According to the results of the two-years' survey, however, this temperate forest system is in equilibrium, and no pest-control measures are necessary.

The diversity index is easy to calculate but difficult to interpret. It may have merit for some comparisons especially in long term or seasonal surveys at the same locality. However, it is very difficult for comparisons between localities, since biological diversity varies between different habitat types.

There are significant relationships among numbers of moths, mean temperature and mean rainfall. The foliage of many tree species may undergo seasonal changes under the influence of temperature and rainfall changes and correlated with changes in species composition and abundance of leaf-feeding moths. Feeding experiments are

needed for understanding the associations of particular moths with plants.

In predicting or monitoring ecological communities, the relations between species and environmental variables must be quantified. The observed values of one of more environmental variables can be used to predict species abundance. The possibility that plant structure, plant species diversity, or vegetation complexity influence moths diversity needs further study.

Several macroheteroceran groups are easily sampled through light traps and widely dispersed among plant species and niches, making this one of the best terrestrial groups for ecological monitoring.

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臺灣中部梅峯溫帶林大型蛾類之多樣性

林政行

摘要

於1990及1991年間利用燈光誘集的方法在臺灣中部南投縣梅峰定期調查研究蛾類昆蟲相，兩年共採得200種大型蛾類，其中以尺蠖蛾及夜蛾佔最多數。探討物種豐度關係及計算幾種多樣性指數各種蛾類之豐度分布適合對數常態分布，蛾類昆蟲群聚在溫帶森林生態系中呈高度的平衡狀態。採集的蛾類昆蟲數與氣候因子特別是溫度與雨量有顯著的相關性。本文附上樣區附近的植物相及各種蛾類昆蟲幼蟲之可能的食料植物提供參考並討論利用蛾類昆蟲做為生態監測的可能性。

關鍵詞：大型蛾類、群聚、多樣性、幼蟲食料植物、生態監測、臺灣。

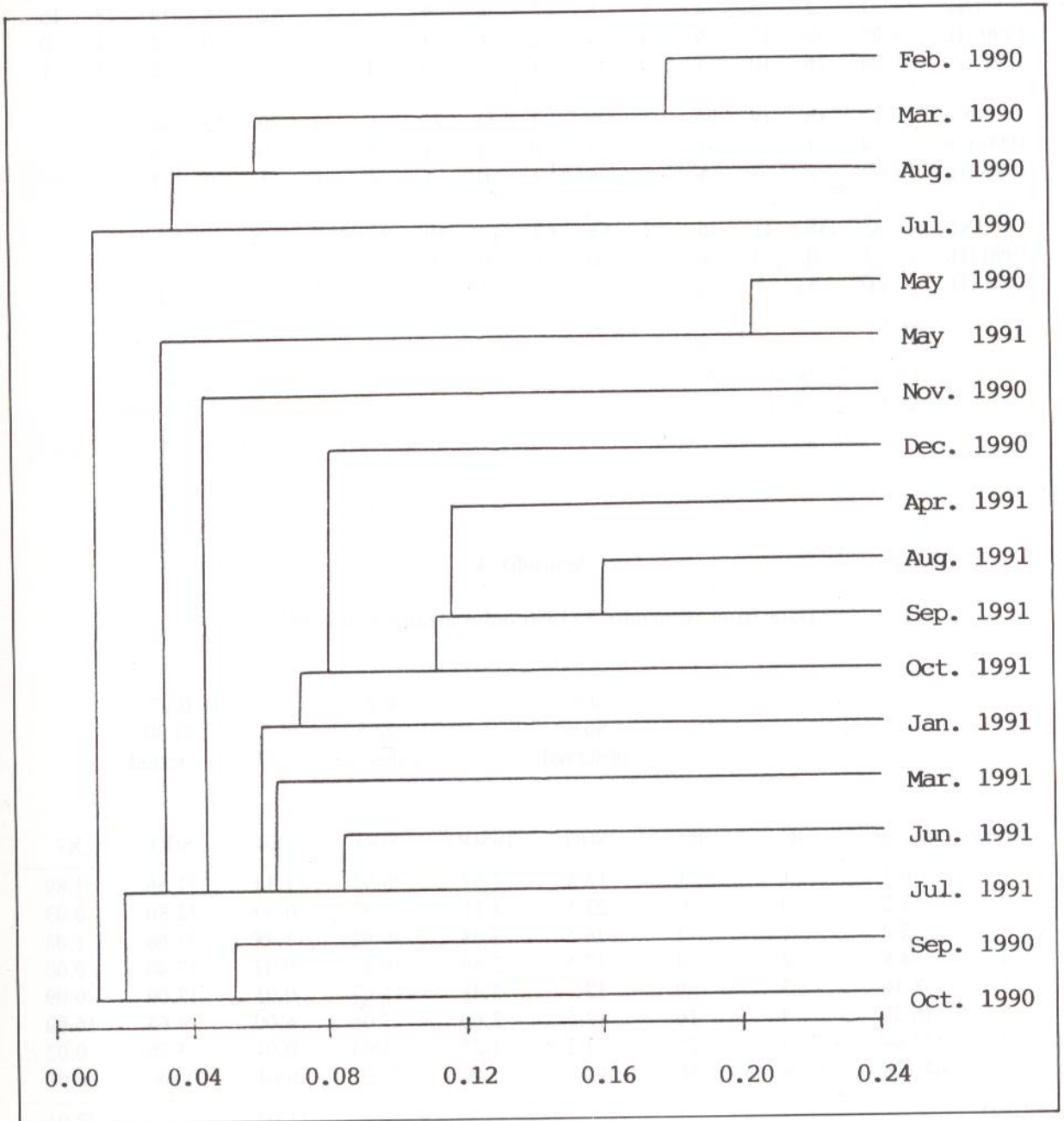
Appendix 1

Trellis diagram of sorenson's indices of similarity for taxonomic comparison of moths sampled during 18 months of 1990-1991 at Meifeng, Nantou, Taiwan.

Month Sample /Year No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Feb. 1990	1	1.00																
Mar.	2	.1818	1.00															
May	3	.0162	.0112	1.00														
Jul.	4	.0298	.0292	.0350	1.00													
Aug.	5	.0532	.0676	.0294	.0576	1.00												
Sep.	6	.0089	.0192	.0252	.0238	.0460	1.00											
Oct.	7	.0000	.0000	.0290	.0390	.0000	.0530	1.00										
Nov.	8	.0160	.0108	.0154	.0200	.0244	.0322	.0290	1.00									
Dec.	9	.0258	.0000	.0048	.0000	.0174	.0152	.0168	.0486	1.00								
Jan. 1991	10	.0232	.0000	.0152	.0050	.0206	.0244	.0198	.0476	.0606	1.00							
Mar.	11	.0098	.0000	.0072	.0000	.0078	.0000	.0326	.0702	.0250	.0250	1.00						
Apr.	12	.0162	.0000	.0165	.0262	.0000	.0128	.0244	.0350	.0986	.0688	.0688	1.00					
May	13	.0084	.0000	.0206	.0108	.0238	.0084	.0108	.0446	.0480	.0126	.0464	.0686	1.00				
Jun.	14	.0000	.0000	.0204	.0106	.0104	.0076	.0102	.0380	.0464	.0108	.0606	.0504	.0628	1.00			
Jul.	15	.0078	.0000	.0238	.0212	.0136	.0272	.0328	.0442	.0818	.0288	.0738	.0588	.0626	.0850	1.00		
Aug.	16	.0000	.0000	.0132	.0400	.0126	.0260	.0390	.0484	.0874	.0698	.1000	.1262	.0582	.0742	.1246	1.00	
Sep.	17	.0000	.0000	.0194	.0186	.0172	.0228	.0504	.0534	.0854	.1200	.0700	.1104	.0478	.0618	.0816	.1614	1.00
Oct.	18	.0000	.0000	.0178	.0410	.0388	.0506	.0576	.0640	.0574	.0608	.1088	.0488	.0420	.0600	.1200	.1146	1.00

Appendix 2

Dendrogram of taxonomic similarity of moth sampled during 18 months 1990-1991 at Meifeng, Nantou, Taiwan.



Appendix 3

Moth collection data at Meifeng during 1990-1991.

(X):	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1990 (f):	25	20	12	9	4	4	2	6	4	2	0	2	0	0	1	0
1991 (f):	24	16	10	11	4	5	1	2	0	4	6	0	2	2	5	1
(X):	17	18	19	20	21	22	23	24	25	26	28	29	32	34		
1990 (f):	4	1	1	1	1	2	0	1	1	0	1	0	1	0		
1991 (f):	2	2	3	1	1	3	2	0	1	1	1	1	0	1		
(X):	35	38	41	46	52	65	69	72	89	92	128					
1990 (f):	1	0	0	0	1	0	1	0	0	0	1					
1991 (f):	0	3	1	1	0	1	0	1	1	1	0					

Appendix 4

Data from Appendix 3 (1990 only) arranged in octaves.

Octave	no/sp.	R	R ²	S(R)	lnS(R)	S(R)	X ²	S(R)	X ²
1	0-1	-1	1	12.5	2.52	20.92	3.38	21.66	3.89
2	1-2	0	0	22.5	3.11	22.5	0.00	23.30	0.03
3	2-4	1	1	26.5	3.28	20.92	1.48	21.66	1.08
4	4-8	2	4	17.5	2.86	16.81	0.03	17.40	0.00
5	8-16	3	9	12	2.48	11.67	0.01	12.09	0.09
6	16-32	4	16	13.5	2.60	7.01	6.00	4.63	16.99
7	32-64	5	25	3.5	1.25	3.64	0.01	3.76	0.02
8	64-128	6	36	1.5	0.40	1.63	0.01	1.68	0.02
Total							11.02		22.91

Appendix 5

Data from Appendix 3 (1991 only) arranged in octaves.

		a =		0.21		0.21			
		So =		20		21.16			
		observed		expected		expected			
Octave	no/sp.	R	R ²	S(R)	lnS(R)	S(R)	X ²	S(R)	X ²
1	0-1	-1	1	12	2.48	19.13	2.66	20.25	3.38
2	1-2	0	0	20	2.99	20	0.00	21.16	1.22
3	2-4	1	1	23.5	3.16	19.13	0.99	20.25	0.16
4	4-8	2	4	16.5	2.80	16.76	0.00	17.74	0.08
5	8-16	3	9	20.5	3.02	13.45	3.69	14.22	2.77
6	16-32	4	16	18.5	2.91	9.88	7.52	10.45	0.77
7	32-64	5	25	5	1.61	6.64	0.40	7.03	0.58
8	64-128	6	36	4	1.39	4.09	0.00	4.32	0.02
Total							15.28	6.96	

Appendix 6

Species diversity indices for moths at Meifeng (1990)

Index	Feb.	Mar.	May	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
N	19	3	361	53	66	245	121	388	79	1351
S	7	2	35	16	22	35	23	66	29	146
N/S	2.7	1.5	10.3	3.3	3.0	7.0	5.3	5.9	2.7	9.1
Richness										
R1	2.04	0.91	5.78	3.73	5.13	4.89	3.18	10.91	6.38	20.17
R2	1.61	1.15	1.84	2.14	2.84	1.89	1.80	3.35	3.24	3.99
Diversity										
λ	0.23	0.33	0.08	0.10	0.06	0.10	0.08	0.04	0.05	0.03
H	1.61	0.64	2.86	2.41	2.82	2.83	2.72	3.63	3.01	4.24
N1	5.00	1.89	17.56	11.17	16.88	16.99	15.11	37.92	20.32	69.45
N2	4.28	3.00	12.70	10.06	16.85	10.25	12.71	28.58	17.85	39.03
Evenness										
E1	0.82	0.92	0.81	0.87	0.91	0.79	0.86	0.86	0.89	0.85
E2	0.71	0.95	0.50	0.69	0.77	0.48	0.65	0.65	0.70	0.47
E3	0.67	0.89	0.48	0.68	0.76	0.47	0.64	0.64	0.69	0.47
E4	0.85	1.59	0.72	0.90	1.00	0.60	0.84	0.75	0.88	0.56
E5	0.81	2.25	0.70	0.89	1.00	0.57	0.82	0.74	0.87	0.55

Appendix 7

Species diversity indices for moths at Meifeng (1991)

Index	Jan.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
N	43	239	111	289	368	248	110	66	106	1565
S	20	38	39	41	51	51	40	31	35	144
N/S	2.2	6.2	2.8	7.0	7.2	4.9	2.8	2.1	3.0	10.9
Richness										
R1	5.05	6.77	8.03	7.05	8.49	9.06	8.15	7.23	7.29	19.43
R2	3.04	2.47	3.69	2.41	2.68	3.25	3.65	3.87	3.39	3.63
Diversity										
λ	0.10	0.07	0.06	0.05	0.03	0.04	0.04	0.05	0.11	0.02
H	2.53	3.00	3.17	3.24	3.53	3.46	3.32	3.10	2.80	4.26
N1	12.60	20.16	23.91	25.64	34.20	31.34	27.92	22.20	16.94	71.41
N2	9.60	15.05	17.15	20.54	30.26	22.29	24.88	10.36	8.47	47.99
Evenness										
E1	0.85	0.83	0.86	0.87	0.90	0.88	0.90	0.90	0.79	0.85
E2	0.63	0.53	0.61	0.63	0.67	0.62	0.69	0.72	0.48	0.49
E3	0.61	0.52	0.60	0.62	0.66	0.62	0.69	0.71	0.47	0.49
E4	0.76	0.75	0.71	0.80	0.89	0.70	0.89	0.92	0.49	0.67
E5	0.74	0.73	0.70	0.79	0.88	0.69	0.88	0.92	0.46	0.66

Appendix 8

Correlation between number of moth and 1990 mean monthly rainfall and temperature at Meifeng.

Index	Feb.	Mar.	May	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
N	19	3	361	53	66	245	121	388	79	1335
S	7	2	35	16	22	35	23	66	29	146
N/S	2.7	1.5	10.2	3.3	3.0	7.0	5.3	5.9	2.7	9.1
Rainfall	131.6	168.1	168.1	89.7	761.1	414.1	26.8	7.6	7.2	$r=0.3962$
Temp.	10.45	10.20	14.8	17.3	17.55	16.1	15.15	13.35	9.75	$r=0.7165$

Appendix 9

Correlation between number of moth and 1991 mean monthly rainfall and temperature at Meifeng.

Index	Jan.	Mar.	Apr.	may	June	Jul.	Aug.	Spt.	Oct.	Total
N	43	237	111	289	368	248	110	66	106	1565
S	20	38	39	41	51	51	40	31	35	144
N/S	2.2	6.2	2.8	7.0	7.2	4.9	2.8	2.1	3.0	10.9
Rainfall	130.5	101	160.9	301.4	409.1	283.5	117	116	137	r=0.7165
Temp.	9.4	12.2	14.15	15.9	16	16.9	16.5	15.85	12.6	r=0.8861
1990	r(N :rainfall) = 0.3962									
1991	r(N :rainfall) = 0.7165									
1990 + 1991	r(N :rainfall) = 0.5634									
1990	r(N :temp.) = 0.7165									
1991	r(N :temp.) = 0.8861									
1990 + 1991	r(N :temp.) = 0.8035									
1990	r(N/S:rainfall) = 0.5894									
1991	r(N/S:rainfall) = 0.7336									
1990 + 1991	r(N/S:rainfall) = 0.6459									
1990	r(N/S:temp.) = 0.8684									
1991	r(N/S:temp.) = 0.9225									
1990 + 1991	r(N/S:temp.) = 0.8813									